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Solar energy outlook in Malaysia

Shing Chyi Chua*, Tick Hui Oh

Faculty of Engineering & Technology, Multimedia University, Bukit Beruang, 75450 Melaka, Malaysia

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ABSTRACT

Predicted to be the clean energy of tomorrow, solar energy has been in the forefront of energy development in many developed countries and a potential source of energy to developing countries like Malaysia. This paper presents Malaysia's solar energy or solar photovoltaic developmental outlook. The study is done by first looking into the country's energy policies related to solar energy. Key players in the solar energy development such as government institutions are introduced. Early solar energy programmes and a key project called Malaysia Building Integrated Photovoltaic (MBIPV) as well as its successful initiatives will be presented. Measures which have taken by the government of Malaysia including attractive incentives to encourage solar photovoltaic development, the country's potential in solar energy, foreign investments and future directions as well a feed-in tariff scheme will be presented in length to provide a broad spectrum of solar energy development in Malaysia. The outlook has been positive and the country is active in promoting solar as an alternative energy and is aware of benefits it will bring toward its economic development in the future.

Contents

* Corresponding author. Tel.: +60 6 2523331; fax: +60 6 2316552.
E-mail address: scchua@mmu.edu.my (S.C. Chua).

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1. Introduction

Malaysia is a country in the Southern Asia which comprises Peninsular Malaysia, Sabah and Sarawak (both of which make up East Malaysia) separated by the South China Sea. It has a total area of 329,847 km^2 [1]. The tropical climatic condition in Malaysia is favorable for the development of solar energy due to abundant sunshine with the average irradiance per year of 1643 kWh/m^2 [2]. Solar energy or solar photovoltaic (PV) electricity generation is a form of renewable energy (RE) which is clean, non-depleting and does not emit any greenhouse gases (GHGs) since it generates energy directly from the sun by means of PV effect. The solar PV market has been booming over the last decade and the trend is forecasted to accelerate in the coming years. By the end of 2008, the global cumulative capacity for PV power was approaching 15 GW as depicted in Fig. 1. Europe is leading the way with more than 9 GW, representing over 65% of the global cumulative PV installed capacity with Germany and Spain collectively accounting for more than 90% of the continent's total capacity. Japan accounted for 2.1 GW and US 1.2 GW, representing 15% and 8%, respectively, of the global cumulative PV power installed [3].

Between 2009 and 2030, the global primary energy consumption is expected to rise by 1.6% annually and Malaysia's electricity demand is expected to reach 18,947 MW in 2020 and 23,092 MW in 2030 which is 35% increment from 14,007 MW in 2008 [4]. Currently, Malaysia's electricity capacity through RE stands at 50 MW and it is expected to reach about 2000 MW by 2020. The outlook beyond 2020 is that solar energy is predicted to surpass all other forms of RE in Malaysia. Knowing this imminent scenario, the Government of Malaysia (GoM) will be instituting a RE policy in the coming 2011 including a feed-in tariff (FiT) mechanism. Different forms of RE will be given their share in the FiT mechanism with solar PV in the forefront. This paper will look into Malaysia's solar energy development from various angles. Section 2 presents the policies implemented by the GoM in its energy development, which will lead us to see a clearer picture how solar energy will be the main RE of the future. Section 3 discusses key government institutions and other players in solar PV development while Section 4 presents the programmes and initiatives. Measures which have been implemented by the GoM including incentives offered to promote solar energy and directions in the future will be presented in Section 5. Lastly, concluding remarks in Section 6.

2. Energy policies

Malaysia's framework for energy development started when petroleum was found. Since then, several policies had been implemented such as National Petroleum Policy 1975, National Energy Policy 1979, National Depletion Policy 1980, Four Fuel Diversification Policy 1981, Renewable Energy (RE) as the Fifth Fuel Policy 2000 (5FP2000), National Biofuel Policy and most recently, National Green Technology Policy 2009 (NGTP2009). Due to the scope of the writing, we will discuss only policies related to solar PV.

In 2001, the GoM introduced the 5FP2000 and RE was made the fifth fuel during the Eight Malaysia Plan (8MP) 2001–2005 due to escalating oil price and environmental degradation. The introduction of 5FP2000 places more concerns on sustainability and energy efficiency (EE) developments, emphasizing RE sources such as biomass, biogas, municipal waste, solar and mini-hydro for electricity generation. Further reading on RE, sustainable energy and Malaysia's energy mix can be found in [5–7].

In August 2006, the Third Industrial Master Plan (IMP3) for the period 2006–2020 was launched. It is a 15 years industry development plan and solar energy has been identified as a new growth area. In IMP3 report, it was reported that the worldwide sales of PV cells and modules totaled USD 10 billion in 2005.

To further demonstrate the government's commitment to promote low-carbon technology and ensure sustainable development while conserving natural environment and resources, NGTP2009 was launched in July 2009 by the Prime Minister of Malaysia, Datuk Seri Najib Tun Abdul Razak. The NGTP2009's goals are aimed at progress and improvements made in major sectors such as energy, buildings, water and waste management, and transportation as well as research and development (R&D), innovation and commercialisation through collaboration with local and multi-national companies by the utilisation of RE and promotion of EE through green technology. One emphasis to green technology is solar PV systems in building designs.

In the coming 10MP 2011–2015, a National RE policy 2011 will be launched. In the Asia-Pacific Economic Cooperation, Expert Group on New and Renewable Energy Technology (APEC-EGNRET) meeting in April 2009 in Honolulu, Hawaii, Malaysia Energy Centre (MEC – it has been rebranded to GreenTech in October 2010) presented a new RE policy and action plan (REAP) by the GoM with the vision of enhancing the utilisation of indigenous RE resources to contribute towards national electricity supply security and sustainable socio-economic development [8]. The Prime Minister has confirmed that the government is in the process of instituting a RE law [9] and one of the new mechanisms under the RE law is the feed-in tariff (FiT). To make this possible, the RE law must make sure that: (i) RE electricity generated must have access to the utility grid, (ii) FiT must be high enough to produce a return on investment, (iii) FiT must be fixed for a long enough period to give certainty and provide businesses with the security for market development, (iv) there must be a degression for the FiT to promote cost reduction in achieving grid parity, and (v) adequate fund is created to pay for the incremental tariff cost (between higher FiT and the displaced electricity cost) and guarantee the payment for the whole contract period, the size of the fund will significantly determine the amount of RE capacity/limit that can be generated [10]. If things go according to plan in 2011 (predicted at second quarter), the imminent introduction of FiT is set to transfigure Malaysia's RE production. It will make it easy for everyone to generate renewable electricity through a wind turbine or solar PV system and sell it back to the national power grid at a premium rate [11]. It is expected all forms of RE will be given their fair share under the FiT mechanism and solar PV is seen as the major contributor if the RE policy were to be implemented nationwide. With solar PV system installed on every roof-top on each household and commercial buildings, the electricity generated, investment opportunity, market and environmental impact through the reduction of GHG emissions this would bring, will definitely put Malaysia as a solar key player of the world.

3. Key players in solar energy development

Energy policy and action plans are proposed and discussed among various key players in government, non-government organizations and industrial sectors. The Malaysian PV industry association (MPIA) [12] is the key player in solar PV development in Malaysia. MPIA was formed in May 2006 to represent, develop and support the growing solar PV industry in Malaysia as well as committed to bring effectiveness and sustainability in the implementation of PV technology.

On the other hand, the Ministry of Energy, Green Technology and Water (MEGTW) and the Energy Commission (EC) are key government institutions for Malaysia's energy sector. EC [13] is established after the Malaysian EC Act 2001 and empowered to regulate, enforce and promote all matters related to the electricity and gas supply industry. The MEGTW [14] was established in

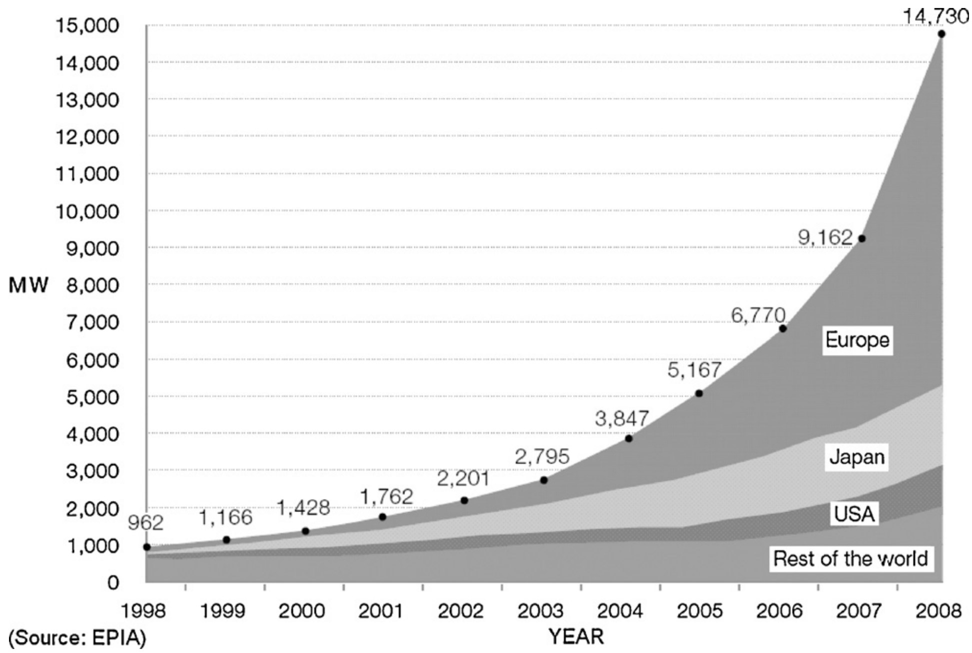


Fig. 1. Global cumulative capacity for photovoltaic power.

April 2009 to administer and manage the Malaysia's energy, green technology and water functions.

On the utility side, Tenaga Nasional Bhd. (TNB) [15], Sabah Electricity Sdn. Bhd. (SESB) [16] and Syarikat SESCO Berhad (SESCO) [17] are the dominant national utility companies for electricity. These utilities are vested with electricity generation, transmission and distribution activities in Peninsular Malaysia, Sabah and Sarawak, respectively. Electricity supply is also complimented by various independent power producers (IPPs), dedicated power producers and co-generators.

For R&D, MEC and Standards and Industrial Research Institute of Malaysia (SIRIM) are the institutions involved in both scientific and economic research for RE and EE. MEC [18] is established since 1997 and administered by MEGTW for the development and coordination of energy research. It aims to be the focal point and catalyst for linkages with universities, research institutions, industry, national and international energy organizations as well as the driving point for sustainable energy solutions. MEC also provides training on the design and installation of grid-connected PV (GC-PV) system and is the first centre in ASEAN to be recognized by the Institute for Sustainable Power accreditation for its GC-PV training. On the other hand, SIRIM Berhad [19] is a wholly owned company of the GoM under the Minister of Finance and functions as the national agency for industrial development in R&D, standards and quality through programmes in technology and standardization.

On the energy promotion and investment side, Malaysian Industrial Development Authority (MIDA) [20] is the principal agency for the promotion of manufacturing and services sectors including solar PV development and investments.

4. Programmes and initiatives in solar PV developments

Solar PV applications were first used for rural electrification and telecommunications back in the early 1980s. In the 1990s, rural electrification programme was undertaken by the Ministry of Rural Development with the aim of providing electrification to remote communities in Malaysia. One third of the Government's total allocation of RM 469 million (USD 145 million) under the 7MP was for rural electrification programmes for the provision of solar powered installations for rural and remote communities [14] including power to individual homes, longhouses, clinics, community halls, rural schools (e.g. Net-School project) and islands (e.g. island electrification with hybrid systems at Pulau Kapas). In 1992, a rural electrification demonstration project for PV power generation system was implemented under the initiatives of Ministry of Energy, Water & Communications (MEWC) and the Japanese Government, represented by New Energy and Industrial Technology Development Organization in Marak Parak, Sabah. The government of Japan has continued to support rural electrification project and recently, Pulau Larapan, an island off the east coast of Sabah has received about RM172k (USD53k) in financial grant for 'Project for the Electrification by Solar Energy' [21]. Other stand-alone solar application projects include: (i) domestic hot water systems (e.g. solar heating for Awana Kijal Golf & Beach Resort installed in 1994), (ii) water pumping, and (iii) drying of agricultural produce (e.g. The Malaysian Agricultural Research and Development Institute had carried out several tests to solar dry food products such as coffee, cocoa beans and paddy, the Forest Research Institute had applied solar dryers for bamboo and Universiti Sains Malaysia had conducted solar drying for rubber) [22]. In July 1998, the first GC-PV was installed in Universiti Tenaga Nasional with a capacity of 3.15 kWp and connected to a 3-phase electricity system. This was followed by two further GC-PV systems installed by BP Malaysia (8 kWp at a BP petrol station) and Universiti Kebangsaan Malaysia (5.5 kWp at Solar Energy Research Park). As of 2006, there are almost 500 kWp of GC building integrated PVs (GC-BIPVs) installed in Peninsular Malaysia, notably the BIPV at Technology Park Malaysia with a 362 kWp capacity [23].

Since the launch of IMP3 which outlines the country's industry development plan from 2006 to 2020, solar energy has been identified as the next growth area. Prior to this, in July 2005, the MBIPV project [24] was launched by MEC and administered by the MEGTW. It is a big scale USD 25 million national initiative by the GoM, jointly co-funded by the Global Environment Facility through the United Nations Development Programme [25], private and public sectors with a deadline in December 2010. The project's objective is to reduce long term cost of BIPV technology in Malaysia which can be achieved through widespread implementation of BIPV applications within building designs and envelopes that will avoid GHG emissions from the country's electricity sector

Table 1
SURIA 1000 calls result information.

Call for bidding	TBCB	ACA	MBI	WP	Type
First call (C1)	40	58	75	13,079 (46.7%)	R
Second call (C2)	60	94	70	13,477 (51.7%)	R
Third call (C3)	90	109	60	14,968 (53.2%)	R&C
Fourth call (C4)	120	175	55	15,053 (57.8%)	R&C
Fifth call (C5)	140	176	50	14,439 (59.9%)	R&C
Sixth call (C6)	340	–	42	–	R&C

Abbreviations: 1. C1: 1st December 2006 to 30th March 2007. 2. C2: 1st June 2007 to 1st October 2007. 3. C3: 3rd December 2007 to 1st April 2008. 4. C4: 2nd June 2008 to 8th October 2008. 5. C5: 1st December 2008 to 1st April 2009. 6. C6: 1st July 2009 to 1st December 2009. 7. TBCB – target BIPV capacity for bidding (in kWp). 8. ACA – actual capacity awarded (in kWp). 9. MBI – maximum bidding incentive (in %). 10. WP – willingness to pay (in RM/kWp and % of total). 11. R – residential only. 12. R&C – residential and commercial.

as well as the creation of environmental and industrial policy in Malaysia. The MBIPV project is expected to induce an increase of BIPV applications by about 330% with a cost reduction of 20% by the year 2010, thus have a significant input on the overall reduction of GHG emissions. Over the lifetime of the project, the energy generated will avoid 65,100 tCO_2 emissions from the country's power sector [22]. During MBIPV's 5-year duration, showcase and demonstration, SURIA 1000, and SURIA for Developers programmes have been implemented.

4.1. Showcase and demonstration programmes

BIPV showcase programme aims to create BIPV success stories and excellent example for public/industry references by offering a total of 100 kWp capacity while BIPV demonstration programme aims to stimulate the local building industry (in private and government sectors) by offering a total of 160 kWp capacity. This consists of 100% technical and financial incentives limited to BIPV system and promotional support as well as up to 28% financial support for supply and installation of BIPV systems. Examples of successful projects include: (i) office – 92 kWp BIPV system at MEC-GEO, (ii) school – 4.4 kWp BIPV system at SMK (P) Sri Aman, Petaling Jaya, and (iii) university – 7.36 kWp BIPV system at Monash University, Malaysia. The 92 kWp BIPV system at MEC-GEO is the most significant project so far. GEO (stands for Green Energy Office) building is an administration-cum-research office for MEC, thus called MEC-GEO. MEC-GEO building is the first of its kind in Malaysia and Southeast Asia that integrates EE and RE in one working building and cost RM 20 million (USD 6.2 million). The BIPV panels are all integrated into the building design to provide electricity for the building uses and are connected to TNB grid and help shaves the peak power demand of the grid during the peak daylight hours. The system provides almost 50% of everyday electrical needs.

4.2. SURIA 1000 programme

This is the anchor project under MBIPV launched in 2006. The objective of SURIA 1000 is to see at least 1200 kWp of GC-BIPV systems installed by 2010 compared to the total GC-BIPV systems of 578 kWp in Malaysia. Based on Germany's Rooftop Programme and Japan's Sunshine programme, SURIA 1000 allows homes and offices to be fixed with solar PV roofs to generate energy from sunlight. It is Asia-Pacific's first financial incentive PV programme to be carried out via a bidding process in which the bidding is awarded to those who request for the least financial support from the GoM. Each year, the bidding is opened twice. As of 2006, the cost of a 1 kWp PV system is at least RM28k (USD8.7k) of which 30% is the cost of installation [26]. A household would normally used between 3 kWp and 5 kWp a month and thus a 5 kWp BIPV system will cost at least RM140k (USD43.3k). Due to this, the government provides discount to make the PV system more affordable. The first call provided a discount up to 75% of the price of the PV system and subsequently reduced by at least 5% for the next call. Excess electricity generated is fed back to the TNB grid via net-metering. To date, six calls have been completed and the information of five calls is available in Table 1.

The first two calls of SURIA 1000 were for residential only and starting with the third call, the programme was opened to commercial bidders as well. Residential bidders can bid up to 10 kWp of PV capacity while commercial can bid up to 30 kWp maximum. The PV systems can be mounted in two ways: (i) integrated – the PV acts as the primary building envelope (the roof) or (ii) retrofitted – the PV system is mounted above the existing roof. 54% of the total awarded PV capacity was retrofitted and 46% integrated up to the fifth call. The first five calls of SURIA 1000 showed that: (i) a total of 612 kWp in PV capacity was achieved (target is 450 kWp), (ii) the bidders' willingness to pay increased from 46.7% in the first call to 59.9% in the fifth call of total PV system price, and (iii) the PV system pricing (per kWp) showed fluctuating prices, from first call around RM28k (USD8.7k) to around RM24k (USD7.4k) in the fifth call. Fig. 2 shows the analysis on successful BIPV capacity while Fig. 3 shows the price analysis on successful calls.

Under the SURIA 1000 programme, integrated mounting structure receives 5% extra points as incentive to promote aesthetic BIPV applications and in August 2008, the GoM announced the National Budget 2009 (NB2009) which extended import duty and sales tax exemption on PV systems to PV system importers and PV service providers approved by the EC for products they import for supply to their clients [27].

4.3. SURIA for Developers programme

The SURIA for Developers programme provides opportunity for property developers in Malaysia to develop housing development project which incorporates BIPV. The programme targets a total BIPV capacity of up to 340 kWp capacity with financial incentive amounts to RM 3 million (USD927k) [28]. The call for developers started from July 2007 to January 2008. The developers are

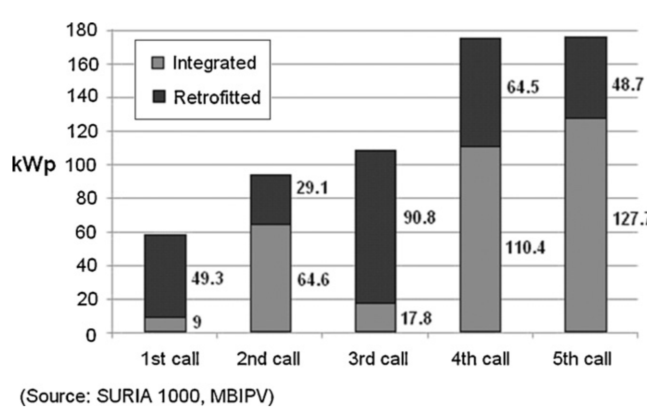
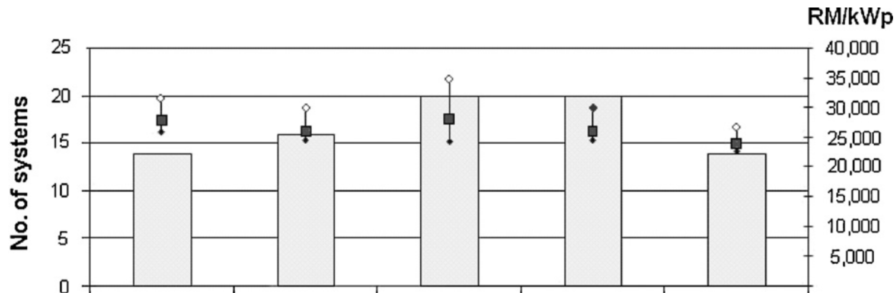


Fig. 2. SURIA 1000: analysis on successful BIPV capacity.



	1st call	2nd call	3rd call	4th call	5th call
■	14	16	20	20	14
◇ Highest	31,746	30,000	34,920	30,039	26,835
■ Average	28,006	26,067	28,135	26,044	24,118
◆ Lowest	26,041	24,836	24,839	24,799	22,844

(Source: Suria 1000, MBIPV)

Fig. 3. SURIA 1000: price analysis on successful calls.

to submit development concepts including architectural drawing, concept and features of solar BIPV, plus indicative cost of solar BIPV (capacity of each house is 4–10 kWp subject to a minimum total of 100 kWp per development). Three housing developers who succeeded are: (i) SP Setia at location Setia Eco. Park in Shah Alam, Selangor which develops 5 kWp PV systems cost over RM170k (USD52.5k) each in 20 of the 39 bungalows, (ii) Putrajaya Perdana at location Precinct 16 of Putrajaya which offers average 5.4 kWp PV modules in 15 bungalows, and (iii) Amarin Wickham at U-Thant area of Kuala Lumpur which incorporates PV cells into the sunshade on the roof of its condominium [29].

4.4. Other initiatives

Other key PV development initiatives under MBIPV include: (i) launching awareness programme (e.g. MEC has worked with the Centre for Education and Training in Renewable Energy and Energy Efficiency to carry out essay and drawing competitions centred on 'BIPV SURIA' or 'Solar BIPV' held between May and June 2007 among secondary school students in the entire country under the Ministry of Education. At the same time, awareness in private school such as Sekolah Sri Cempaka was launched in which the school had taken its own initiative to install a ground mounted PV system as education on solar energy to the students [28]), (ii) setting up of a PV monitoring centre at Universiti Teknologi MARA in November 2006, (iii) organizing PV business development programme, (iii) establishing a training programme in June 2008 with MPIA called Approved Service Provider, (iv) initiating a Quality Assurance Scheme in June 2008, and (v) organizing national PV conference to share knowledge on solar PV technology, policies, market and industry development (e.g. the largest PV conference in Malaysia started in August 2008 and also November 2009 recently). Other efforts include the proposal for PV incentives to be enhanced through the national budget in order to attract investments in PV systems, proposal of changes to the various government agencies on procedures to facilitate PV growth and also working towards a sustainable environment for the widespread use of GC-PV in Malaysia.

In the international PV arena, as of October 2008, Malaysia became a full member of the International Energy Agency Photovoltaic Power Systems (IEA-PVPS) and participated in IEA-PVPS's Programme Task 1, 2, 10, 11 and 13. The mission of the PVPS programme is to enhance the international collaboration efforts which accelerate the development and deployment of PV solar energy as a significant and sustainable renewable energy option. The realistic target until 2020 is to install cumulative of 20 MWp GC-PV capacity in Malaysia. Since the MBIPV project ends in December 2010, it is thus a reference for the development of future framework for national BIPV programme in the 10MP and beyond.

5. Measures in solar PV developments

There are at least four measures which have been implemented to support solar PV in Malaysia context: (i) fiscal incentives, (ii) intellectual property protection, (iii) investment grants, and (iv) net-metering. Other measures which may not be described can be found in [30,31].

5.1. Fiscal incentives

The MEGTW is responsible for the implementation of national policies relating to RE and EE. Attractive incentives are offered in the generation of RE as well as encouraging EE among energy producers and users in order to ensure sustainable economic development. During the 8MP, the development of RE was stressed and fiscal incentives was first provided in NB2001. From the guidebook on incentives for RE and EE in Malaysia [32], as of 2009 under NB2009, the incentives granted include: (i) Pioneer Status, (ii) Investment Tax Allowance, and (iii) Exemption from payment of Import Duty and/or Sales Tax on machinery, equipment, materials, spare parts and consumables. All applications are effective within August 2008 to December 2010. In the recently announced NB2011, these tax incentives have been extended by another 5 years.

5.1.1. Pioneer Status (PS)

The PS provides exemption from income tax (25% from 2009 onwards) on 100% of statutory income for 10 years (originally from 70% of statutory income for 5 years). Accumulated losses and unabsorbed capital allowances incurred during the pioneer period can be carried forward and deducted against post pioneer income of the company. The exemption commences from the date the company's roof mounted PV modules makes its first sales or date of first invoice of company.

5.1.2. Capital Allowance (CA) and Investment Tax Allowance (ITA)

Under ITA, 100% of qualifying capital expenditure (originally 60% of qualifying capital expenditure) incurred within a period of 5 years can be utilised against 100% of the statutory income (originally 70% of statutory income) for each year of assessment. Unutilised allowances can be carried forward to subsequent years until fully utilised. Qualifying capital expenditure means capital expenditure incurred on buildings, plant and machinery used for

the purpose of RE activities. Under the NB2008, RE generation for own use has been enhanced to ITA. This means that companies which invest in GC-BIPV for their own use can get ITA benefits on top of the CA they normally enjoy. This is equivalent to a "double tax deduction". The corporate tax rate is 26% for 2008, and 25% for 2009 and beyond.

5.1.3. Import Duty and Sales Tax Exemption (ID-STE)

Companies generating RE can also apply for ID-STE on imported machinery, equipment, materials, spare parts and consumables used directly in the generation process and that are not produced locally. For locally purchased machinery, equipment, materials, spare parts and consumables, full exemption is given on sales tax. Exemption is given for a period of one year, commencing from the date the application is received by MIDA. Under NB2009, this incentive has been extended to grant exemption of import duty and/or sales tax to Third Party Distributors (TPDs) of the relevant products as applicable for solar (PV or thermal) systems.

The energy generation using RE resources is an activity promoted under the Promotion of Investments Act 1986 (PIA86). Commercial and industrial business entities undertaking energy generation using RE resources such as solar power, whether for electric generation to sell to local utility providers through the distribution grid or for their own usage are eligible to apply for the incentives. For energy services companies (ESCOs) that provide consultancy and advisory services as well as project management services relating to the conservation or EE and companies that incur capital expenditure for conserving energy for own consumption, they are also eligible to be considered for incentives under the PIA86. It was reported in [22] that companies implementing RE projects including solar PV would have their internal rate of return increased up to 2% and payback periods reduced as much as three years for tax exemptions on eligible costs alone. The burden of a company's annual taxes will be lower, 32–53% via ITA.

These incentives can be divided into two main categories: (i) incentives for Companies (companies locally incorporated under the Companies Act 1965, being classified as Sykt. Bhd. or Sykt. Sdn. Bhd.), and (ii) incentives for importers or manufacturers as TPDs. Therefore, the incentives offered benefit only companies that generate energy from RE resources. However, in 2009 under NB2009, the incentives were enhanced as follows: (i) ID-STE on solar PV system equipment (e.g. PV modules, GC-PC inverters, etc.) for use by third parties was given to importers, including PV service providers, approved by the EC, and (ii) STE on the purchase of solar heating system equipment (e.g. solar water heaters, solar process heaters, solar agricultural product dryers, etc.) from local manufacturers [32].

5.2. Intellectual property (IP) protection

On the IP front, foreign companies investing in RE and EE in Malaysia will find protection of patents, trademarks, industrial designs, copyrights, geographical indications, and layout designs of integrated circuits. Malaysia is a member of the World Intellectual Property Organization and a signatory to the Paris Convention and Berne Convention that govern IP rights. Malaysia is also a signatory to the Agreement on Trade-Related Aspects of Intellectual Property Rights, signed under the auspices of the World Trade Organization. The GoM has guaranteed all existing and potential investors of its continued pro-business policies and incentives packages formulated and implemented by the federal government [27].

5.3. Investment grants

Providing investment grants is usually the initial step and a promotional tool for most countries to start out any kind of business. The SURIA 1000 programme provides investment grants up to 75% for up to 1.5 MWp during the first call and a degression of the share of grant every six months during successive call period to reflect on the expected price reductions. The three development projects under SURIA for Developers also benefit from a 30% to 35% subsidy [29].

5.4. Net-metering

Net-metering allows two-way meters to be installed and deducts PV generated electricity as a part of the building energy consumption. Net-metering and inter-connection (direct-feed or indirect-feed) to the local distribution grid has already been accepted by the utilities. Since 2008, it is permitted to connect PV power generating equipment to the local utilities (TNB, SESCO and SEB) for low voltage distribution supply network (230/400 V 1-phase/3-phase).

6. The way forward

What are the directions of solar PV developments in Malaysia? This section provides a few important indicators on potential, opportunities and development trend of solar PV in Malaysia.

6.1. Solar energy potential study

Solar energy is projected to supply 30% of the world's energy demand by 2050, and create an industry far bigger than the global automotive industry. It is also forecasted to provide about 64% of the electricity supply in 2100 as depicted in Fig. 4 [27].

A study which has been conducted under MBIPV project shows that potential in producing electricity through solar PV system in Malaysia are among the highest worldwide. In May 2006, IEA-PVPS Programme Task 10 prepared a comparison of environmental indicators for 41 selected cities in the Organization for Economic Cooperation and Development (OECD) countries [33]. The objective of Task 10 is to enhance the opportunities for wide-scale, solution-oriented application of PV in the urban environment as part of an integrated approach that maximizes building EE, solar thermal and PV usage. Under MBIPV project, selected Malaysian cities (i.e. Kota Kinabalu, Penang, Kota Bahru, Kuching, Johor Bahru, Kuantan, Melaka and Kuala Lumpur) underwent similar measurements [34] and later compared to the results of the IEA-PVPS Task 10 report. The PV systems investigated are the standard polycrystalline silicon modules and standard GC inverters. The IEA-PVPS study considered two common types of PV applications: (i) roof-top application with a tilt angle of 30° (the investigations in Malaysia uses a modified tilt angle of 10° for locations around the Equator), and (ii) facade application with a tilt angle of 90°. From the study, it is found that the:

(i) Annual energy output for the selected cities in Malaysia varies about 1170 kWh/kWp to 1600 kWh/kWp for roof-top systems while about 630 kWh/kWp to 830 kWh/kWp for facade systems as shown in Fig. 5 and Fig. 6, respectively, which made Malaysia cities among the top half for the annual energy output estimated for roof-top applications among the cities surveyed as compared to [33]. The highest annual energy output from this study is Kota Kinabalu.
(ii) Energy payback time ranges from 1.6 to 2.2 and from 3 to 4 years for roof-top systems and facade systems, respectively. This is considerably shorter than the expected 30 years lifetime of the installations and thus energy input for manufacturing and installation of PV systems can be recovered well before 30 years.

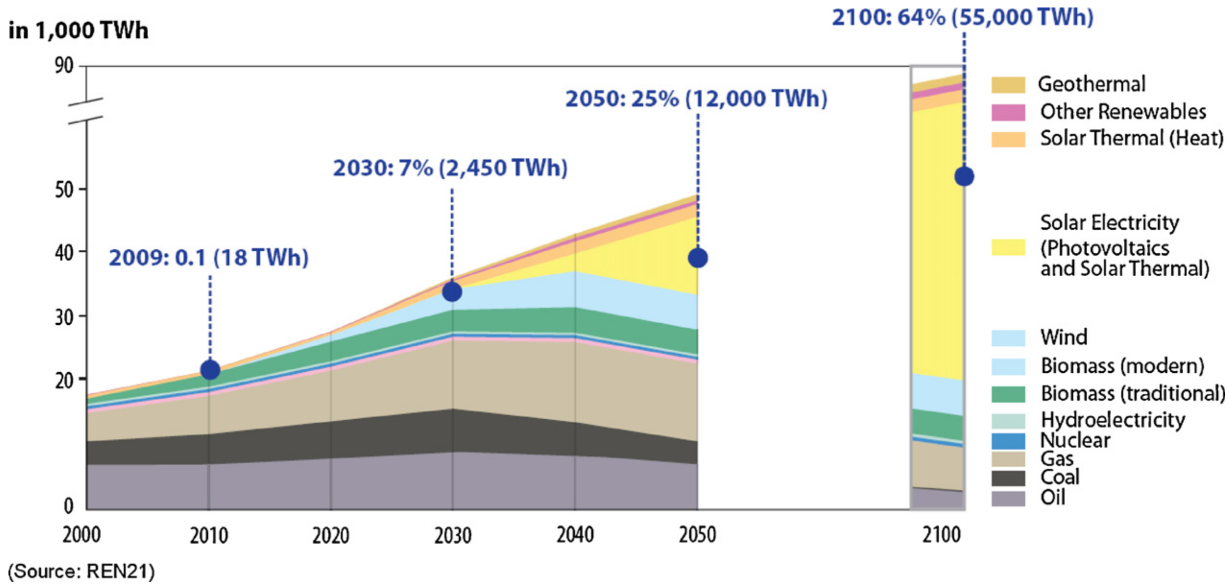


Fig. 4. Electricity supply by Global Renewable Technologies. (For interpretation of the references to colour in this figure's artwork, the reader is referred to the web version of the article.)

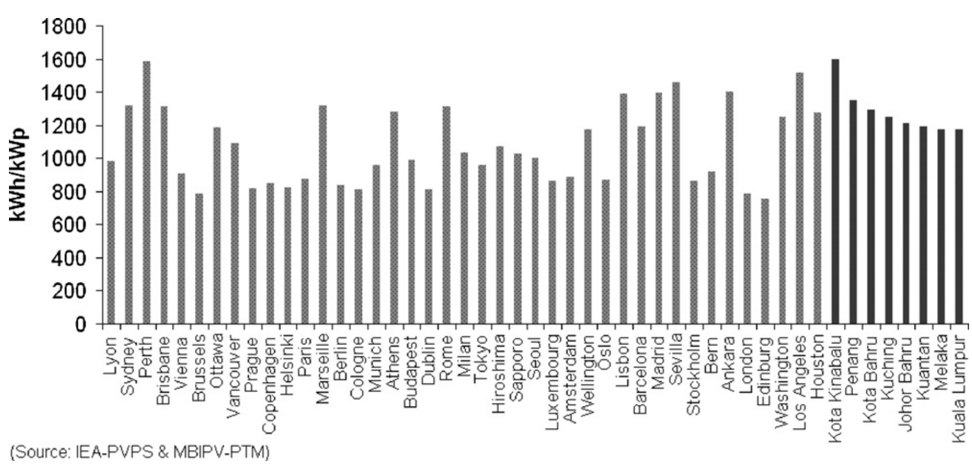


Fig. 5. Annual energy output (Roof-top systems).

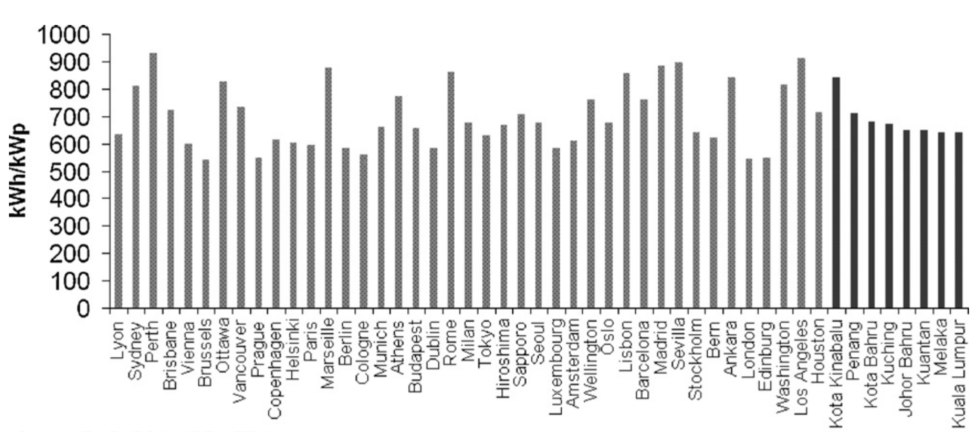


Fig. 6. Annual energy output (Façade systems).

Table 2
Information of FDIs.

Company	Origin	Location	FDI, RM' bil (USD' bil)	Employee	Start
First Solar	US	Kulim, Kedah	2 (0.6)	1200	2008
Q-Cells	Germany	Selangor	5 (1.5)	3500	2009
Sunpower	US	Rembia, Melaka	5 (1.5)	5500	2010
Tokuyama	Japan	Bintulu, Sarawak	1.8 (0.6)	500	2011

(iii) The CO_2 mitigation ranges from 20 to 40 tCO_2 for roof-top installations and from 10 to 20 tCO_2 for facade systems. Thus, CO_2 mitigation potential in Malaysia is relatively high.

6.2. Domestic and foreign direct investments

Currently, global demand for solar PV modules and silicon has exceeded supply and production. Global solar cell technology sales is projected to reach USD 38 billion by 2010, almost triple the USD 10 billion solar cell revenue of 2005 based on forecast in the IMP3. In South-East Asia, Malaysia's current GC installed solar cell capacity of 480 kWp ranks second behind Thailand's 2 MWp capacity. Regardless of the limits and constraints, Malaysia does have the potential to become a major player in the solar cell industry [35]. Recognizing the opportunity, the IMP3 was launched and solar PV was identified as one of the focused technologies. To date, there are four leading global PV enterprises in Malaysia – First Solar, Sunpower, Q-Cells and Tokuyama (refer Table 2). Their collective FDI is equivalent to about RM 14 billion (USD 4.3 billion) and created about 11,000 high skilled jobs.

First Solar is the first global PV company in Malaysia and started its four manufacturing plants in Kulim, Kedah, Malaysia in 2007 which cost an estimated USD 680 million. Completed in 2009, the four plants produces 854 MW from solar modules and the GoM has granted a 15-year income tax holiday as an incentive. Based on good supports seen from the four plants in terms of workforce, infrastructure and government incentives, First Solar added another two new plants in Kulim, which will contribute towards a total 1282 MW capacity in 2011 [36].

Other foreign investments include GEWD of Solarfabrik (Germany) and ReneSola (China). It is estimated that by 2011, Malaysia will be among the top five solar PV manufacturer worldwide following China and Germany (as in Fig. 7) with the local PV industry contributing up to 4% to the national GDP by 2020 through revenues exceeding RM 500 billion (USD 154.5 billion) [27].

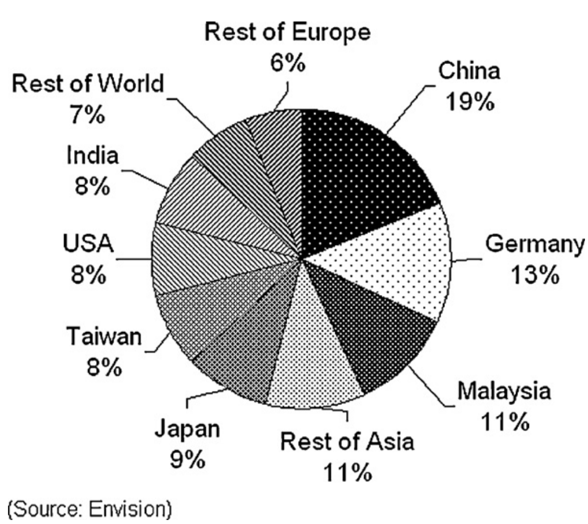


Fig. 7. Estimated PV production in 2011.

On the local investment, it was reported that Berjaya Solar Sdn. Bhd., a wholly owned subsidiary of Berjaya Corporation Berhad had announced the proposed development of a first large-scale 10 MW ground-based solar PV power plant at Bukit Tagar, Selangor, estimated to cost approximately RM 180 million (USD 55.6 million). The proposal have been submitted to MEGTW and served as a precursor for developing a 50 MW PV power plant. Pending and subject to approval of the FiT mechanism, Berjaya Solar is expected to commence development of the power plant in the second half of 2010 and connected to the national grid to supply electricity nationwide by 2011 [37]. Other local PV industry players in products manufacturing, supply or trading includes Polytool, Solartif, Channel Systems and Compo Enterprise.

6.3. Solar PV as main RE

REAP has been established under the NGTP2009 where biomass, biogas, municipal solid waste, solar and mini-hydro are identified. By 2015, the estimated potential for electricity from biomass, biogas, mini-hydro and solid waste is estimated to be 330 MW, 100 MW, 290 MW and 200 MW, respectively. Solar PV is estimated to have a cumulative capacity of 55 MW by 2015. Beyond 2020, it is predicted that solar energy will surpass all other forms of REs in Malaysia as illustrated in Figs. 8 and 9 [38]. By 2050, the total annual electricity generation from solar PV alone will contribute more than one third among the REs. Coincidently, foreseeing this trend, the MPIA have proposed that solar PV be added into the current energy mix (oil, natural gas, coal, hydro power and RE) as a separate energy apart from REs during a discussion with the MEGTW [39].

6.4. Post MBIPV scenario

The MPIA during its meeting with MEGTW in August 2009 had discussed on the implementation of FiT and post MBIPV project scenario [39]. The MPIA proposed for an establishment of a RM 1 billion (USD 309 million) Solar Initiative Fund (SIF), the implementation of a multi-megawatts GC solar system for peak load leveling and suggestion to include solar PV as part of Malaysia energy mix. Due to unclear direction of solar BIPV at the end of MBIPV project, the SIF is proposed as a post MBIPV initiative in order to help fund future BIPV projects. It is proposed that this fund be parked under financial institutions and available as long term loan up to 15 years or subsidy to individual or companies interested in installing solar PV system of 3–20 kWp capacity covering both GC and BIPV system on existing or new roof-tops for own use and also off-grid applications. MPIA believed that Malaysia could achieve multi-megawatts installations which can be implemented in the same way as IPP but with the aim of using it as peak load leveling of national power grids. With the system connected to TNB, it can help to meet national peak demand and save TNB billions of cost annually by not depending on subsidized gas turbines during peak period. Installation of multi-megawatts PV power system does not require large land space. MEC and IEA international consultant estimated that 6500 MW power can be generated using only 40% (or 25 million) of existing house roof-tops and 5% (or 400,000) of commercial buildings using solar PV module of 100 Wp/m^2 [10].

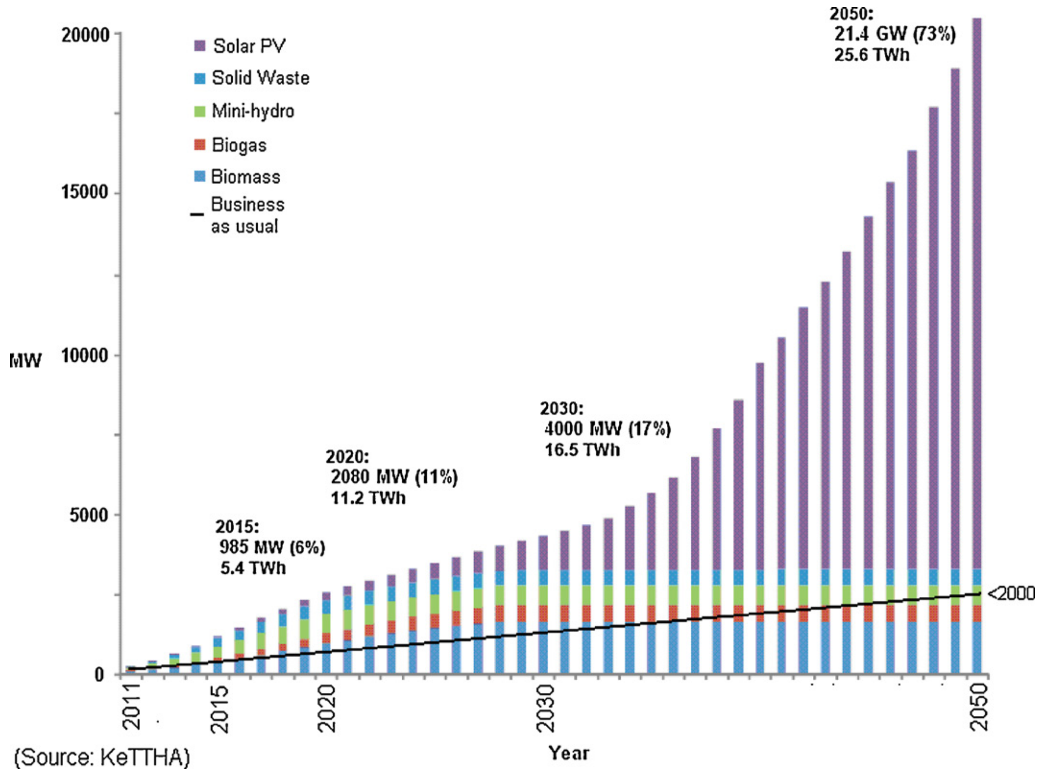


Fig. 8. Cumulative RE installed capacity. (For interpretation of the references to colour in this figure's artwork, the reader is referred to the web version of the article.)

6.5. FiT mechanism

FiT is a mechanism that allows RE payments for electricity in kilowatt-hour (kWh). The FiT promotes electricity export as an investment and thus PV systems can be seen as a profitable business opportunity. Two separate meters are to be installed; the users' monthly billings are paid to the utility on one meter while the utility pays the users' electricity exported to the distribution grid on another meter. The developmental outlook of FiT is spurred by the potential and availability of renewable energies in Malaysia [40–43]. The FiT scheme was implemented in Malaysia in the Small Renewable Energy Power Programme (SREPP) launched in May 2001 to encourage and intensify the utilisation of RE in power generation using biomass, biogas, municipal waste, solar, mini-hydro and wind. Since the launch of SREPP, the FiT rate has been capped at RM0.17/kWh (USD0.05/kWh), but was revised to RM0.19/kWh

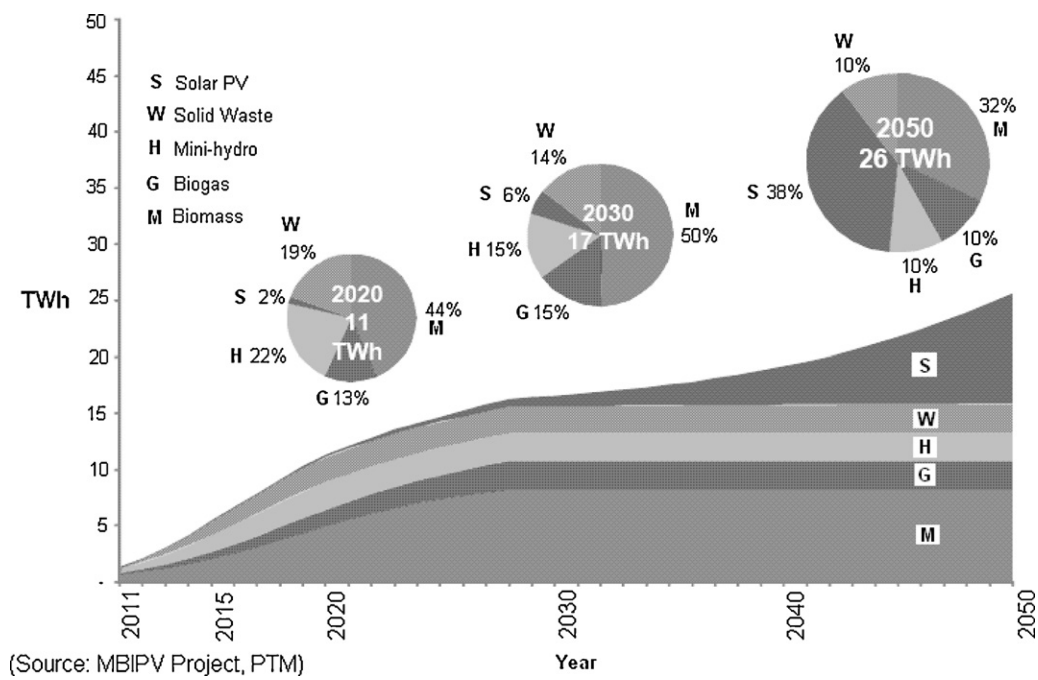


Fig. 9. Annual electricity generation from RE.

Table 3
Proposed FiT rate.

RE	Duration (year)	Tariff[a], RM/kWh (USD/kWh)	Annual degression[a]	Displaced electricity cost[b], RM/kWh (USD/kWh)
Wind	21	0.23–0.35 (0.07–0.11)	1%	0.22 (0.07)
Solar PV	21	1.25–1.75 (0.39–0.54)	6%	0.35 (0.11)
Solid waste and sewage gas	21	0.30–0.46 (0.09–0.14)	1.5%	0.22 (0.07)
Biomass	16	0.24–0.35 (0.07–0.11)	0.2%	0.22 (0.07)
Biogas	16	0.28–0.35 (0.09–0.11)	0.2%	0.22 (0.07)
Geothermal	21	0.28–0.46 (0.09–0.14)	1%	0.22 (0.07)
Mini-hydro	21	0.23–0.24 (∼0.07)	0%	0.22 (0.07)

[a] Subject to final confirmation upon enactment of RE law.
[b] Subject to tariff increment.

(USD0.06/kWh) in 2006 and again to RM0.21/kWh (USD0.07/kWh) in 2007 for biomass and biogas. The price level may have encouraged biomass and biogas, but has not attracted much investment from solar PV as it requires a higher FiT. However, this scenario is expected to change beyond 2011.

During the National PV Conference in November 2009, MEC presented a full FiT scheme which will be introduced and debated in the 2010 year-end Parliament for the 10MP period [44]. A Sustainable Energy Development Authority (SEDA) Act which will solely manage the FiT program will also be tabled. For solar PV, the internal rate of returns by implementing FiT are 5.1% for BIPV, 8.7% for PV on commercial roof-tops, and 10.9% for solar PV plants which is likely ground-mounted. It is estimated that the FiT programme would add 2% to the average electricity tariff in the country. The proposed tariffs will be differentiated by technology and project size as tabulated in Table 3.

FiT's approach provides stable investment climate and it has been proven to generate the fastest, lowest-cost deployment of RE [35]. Countries that have implemented FiT such as Germany, Spain and South Korea have created more employments, great investment market and security as it is non-depletable and also helps to reduce GHG emissions. Therefore, it is considered the most successfully implemented RE policy. With the proposed FiT mechanism in 2011, an annual GC-PV capacity of around 27 MWp by 2015 and 125 MWp by 2020 are to be installed. The off-grid market will still develop and is estimated to be around 2 MWp in 2009 and 3 MWp by 2010, but this will diminish as Malaysia becomes fully electrified in a few years time. GC-PV will be the main market from 2015 onwards, provided FiT policy is truly implemented from 2011 [27]. As outlined by the National Renewable Energy Laboratory (NREL), several key factors will define the successful implementation of FiT: (i) stability – FiT has to be in place at least 5 years to encourage investments, (ii) long-term contract – sufficient time such as 15–20 years must be contracted to allow investors to recover their costs, (iii) adequate energy prices, (iv) annual decreasing payments to encourage rapid deployment and allows for competitions, (v) differentiate payments by technology, project size and resource, (vi) incorporate FiT into utility to guarantee payments, and (vii) proper regulatory framework as outlined in [45]. All of these seem to have been in place and the full FiT scheme is almost definite to change the solar energy market and developments in Malaysia.

6.6. Others

The GoM participated in many international conventions dedicated to global warming such as the Kyoto Protocol to reduce GHG emissions and Montreal Protocol to reduce CFC. Malaysia ratified the Kyoto Protocol in September 2002, the Vienna Convention and the Montreal Protocol in August 1989. Thus, Malaysia has been a keen player towards mitigating global climate change and promoting sustainable environment. The GoM continues to play an active role in RE, EE and sustainable environment including promoting solar PV while pursuing economic development.

7. Conclusions

Malaysia has been dynamic in its energy planning so far by aligning its national energy policies towards global trends and at the same time propagating economic development. Higher fuel prices and depletion of non-renewable fossil fuels have forced the government to consider RE such as solar PV in electricity generation. Various government agencies with feedback from private institutions have been proactive towards drafting energy developmental policy. Government programme such as MBIPV project brings widespread awareness of solar PV and through various initiatives support the PV industry and PV technology deployment. To encourage the growth of PV industry, government's supports through financial incentives has been positive. Attractive incentives and grants are provided to promote solar PV development which has led to lucrative investments. Since Malaysia is encouraging utilisation of RE, the practice of EE and promotion of green technology, solar energy will be the forerunner among other REs due to its limitless and free energy from the sun. Development of solar PV and technology gain great momentum since IMP3 has identified solar as the next growth area until 2020. Solar energy is expected to surpass all other REs in Malaysia by 2050. With investments and energy resources factoring in as well as global energy trend, the promotion solar PV has been encouraging. Soon, the government is set to launch a RE policy including RE act and SEDA act (for FiT) in second quarter of 2011 which sees solar PV as major driving factor. The solar energy development in Malaysia is thus extremely bright and government support remains the key driver for PV market and industry.

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